

MINISTRY OF EDUCATION, SINGAPORE
in collaboration with
UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE
General Certificate of Education Ordinary Level

CANDIDATE
NAME

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CENTRE
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INDEX
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Paper 3 Chemistry

October/November 2019

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name on all the work you hand in.

You may use an HB pencil for any diagrams, graphs, tables or rough working.

Write in dark blue or black pen.

Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

DO NOT WRITE IN ANY BARCODES.

Section A

Answer **all** questions.

Write your answers in the spaces provided on the question paper.

Section B

Answer any **two** questions.

Write your answers in the spaces provided on the question paper.

A copy of the Data Sheet is printed on page 19.

A copy of the Periodic Table is printed on page 20.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

Section A

Answer **all** the questions in the spaces provided.

1 Name the substance that is used to:

(a) reduce iron oxide in a blast furnace

.....

(b) raise the pH of soil in a farmer's field

.....

(c) change glucose into ethanol

.....

(d) change unsaturated vegetable oils into margarine.

.....

[4]

2 Complete Table 2.1 to give the properties of the sub-atomic particles protons, neutrons and electrons.

Table 2.1

property	proton	neutron	electron
relative mass			
relative charge		no charge	

[5]

3 Fig. 3.1 shows apparatus that is used to fractionally distill petroleum into different fractions.

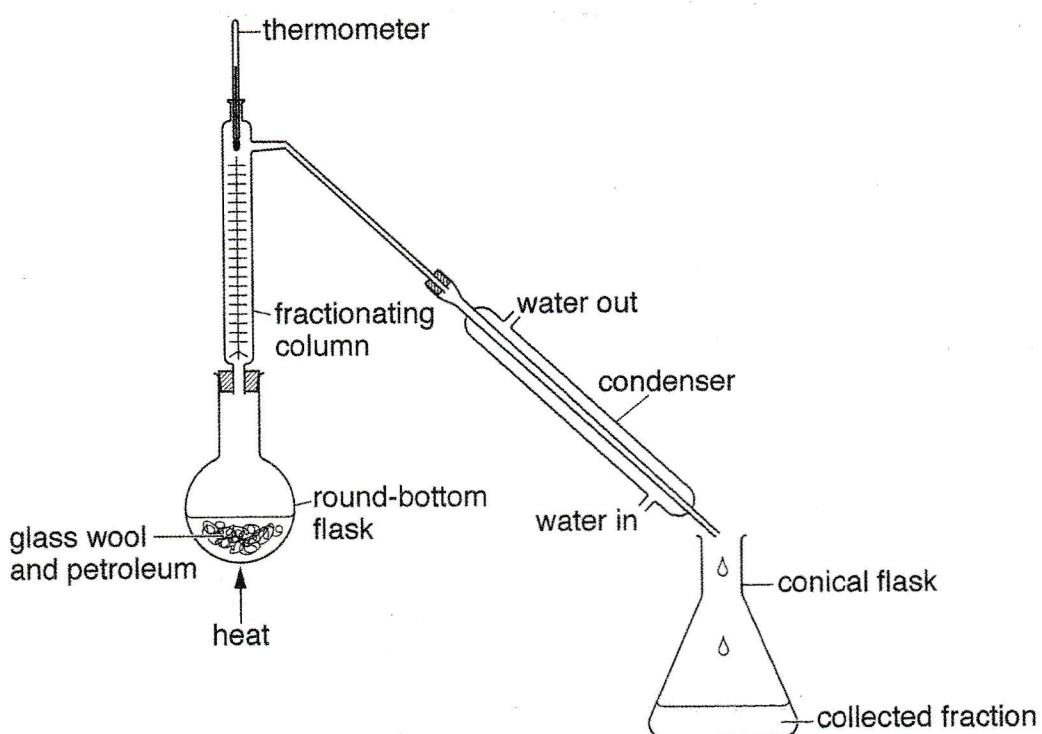


Fig. 3.1

(a) Name the physical property that allows the fractions to be separated.

..... [1]

(b) State why the fractions condense in the condenser.

..... [1]

(c) Explain why the petrol fraction is collected over a range of temperatures rather than at a single temperature.

..... [1]

(d) Name **two** of the fractions, other than petrol, that can be separated by this process.

1.

2.

[2]

(e) When acidified aqueous silver nitrate is added to a sample of aqueous salt, a white precipitate forms.

(i) Name the ion that must be present in the salt.

..... [1]

(ii) The aqueous salt is put in the apparatus shown in Fig. 3.1 instead of petroleum. A colourless liquid collects in the conical flask. This liquid does not form a precipitate when mixed with acidified aqueous silver nitrate.

Name the colourless liquid.

..... [1]

4 (a) A sample of chlorine gas contains two different isotopes of chlorine atoms. Each chlorine atom can become a chloride ion.

Complete Table 4.1 to describe the composition of the chlorine atom and the chloride ion.

Table 4.1

particle	number of		
	protons	neutrons	electrons
a chlorine atom $^{37}_{17}\text{Cl}$	17		
a chloride ion $^{35}_{17}\text{Cl}^-$			

[5]

(b) State **two** ways in which chlorine molecules behave differently when chlorine is above its boiling point and when it is below its melting point. You should refer to the kinetic particle theory in your answer.

1.

.....

2.

.....

[2]

5 Fig. 5.1 describes three of the reactions of a hydrocarbon.

[Relative atomic masses: A_r: H, 1; C, 12; Br, 80]

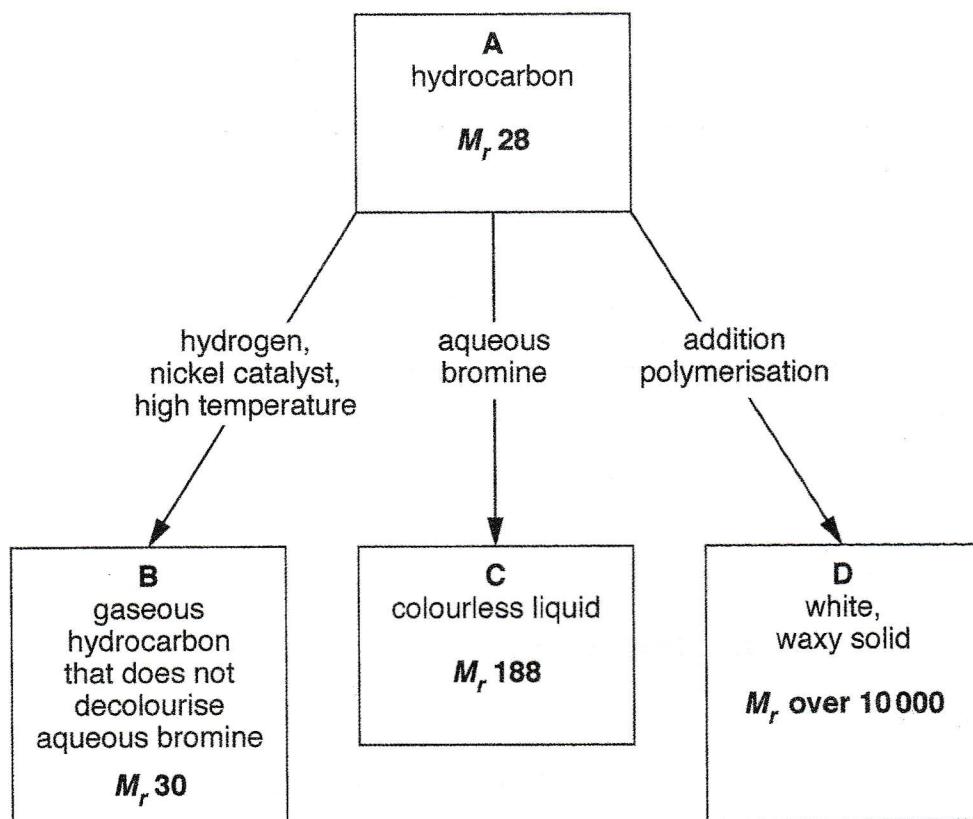


Fig. 5.1

(a) (i) State the name and chemical formula of substances A and B.

	name	chemical formula
A
B

[2]

(ii) State the chemical formula of substance C.

..... [1]

(iii) State the name of substance D.

..... [1]

(iv) State why substance D causes a pollution problem when it is disposed of.

..... [1]

(b) (i) Draw the chemical structure of a molecule of substance C. Show all bonds.

[1]

(ii) Write a chemical equation with state symbols for any **one** of the reactions included in Fig. 5.1.

..... [2]

6 A neutral atom of an element has only two electrons in its third electron shell.

(a) State the atomic number of this element.

..... [1]

(b) State which group and which period of the Periodic Table this element is in.

group

period

[2]

(c) (i) Explain why this element has similar chemical properties to other members of its group in the Periodic Table.

.....
..... [1]

(ii) If the element had the chemical symbol 'Z', state the chemical formula of its:

chloride

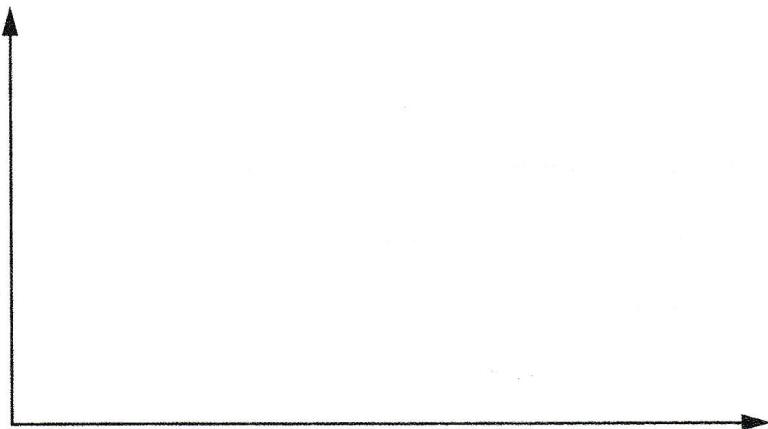
sulfate

[2]

7 A student investigates how the speed of a reaction changes over time.

Dilute hydrochloric acid is put in a flask. Excess powdered sodium carbonate is added to the acid in the flask. While the reacting mixture is fizzing, the flask and contents are carefully put on the pan of a balance. The mass of the flask and its contents are measured regularly until just after the fizzing has stopped.

(a) Sketch the graph that you would obtain from the data collected. Label both axes.



[4]

(b) (i) Explain how your graph shows that the speed of the reaction changes over time.

.....
.....
.....
.....

[2]

(ii) Draw on the graph with a cross when the reaction has stopped.

[1]

(c) Explain how you would calculate the **average** speed of the complete reaction.

.....
.....

[1]

Section B

Answer any **two** questions in this section.

Write your answers in the spaces provided.

8 (a) Nickel has physical properties similar to most other metals. It is between iron and lead in the reactivity series of metals.

(i) State **two** physical properties of nickel.

.....
.....

[2]

(ii) In a reaction between nickel and another chemical, a gas is formed.

Describe how you would test the gas to find out if it is hydrogen or if it is oxygen.

test for hydrogen

.....
.....

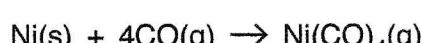
test for oxygen

.....
.....

[2]

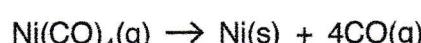
(b) Impure nickel can be purified by the Mond process.

In the Mond process, impure nickel is reacted with carbon monoxide at 50 °C. The gas nickel carbonyl, $\text{Ni}(\text{CO})_4$ is produced.



No other element forms a gas carbonyl under the conditions needed for this reaction.

The gas nickel carbonyl is collected and then heated to about 250 °C. At this temperature the gas decomposes to form pure nickel.



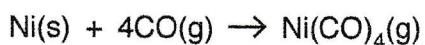
Suggest how the impurities have been separated from the nickel in the Mond process.

.....
.....

[2]

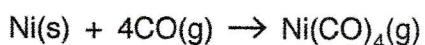
(c) (i) Calculate the mass of nickel needed to produce 1000 g of nickel carbonyl.

[Relative atomic masses: A_r: C, 12; O, 16; Ni, 59]



mass = g [2]

(ii) Calculate the volume of carbon monoxide at room temperature and pressure that is needed to react with this mass of nickel.



The volume of one mole of any gas is 24 dm³ at room temperature and pressure.

[Relative atomic masses: A_r: C, 12; O, 16; Ni, 59]

volume = dm³ [2]

9 (a) State **two** chemical properties of all acids.

1.

2.

[2]

(b) (i) Sodium sulfate is soluble in water. To prepare crystals of this salt, a neutral and colourless solution of sodium sulfate must be prepared.

Describe how you would prepare this sodium sulfate solution from sodium hydroxide solution, a suitable indicator and an acid.

.....
.....
.....
.....
.....
.....
.....

[4]

(ii) Write the chemical equation for your reaction in (b)(i).

.....

[1]

(c) The molar concentration of a solution of sodium hydroxide is 3 mol/dm^3 .

(i) Calculate the mass of sodium hydroxide required to form 4 dm^3 of this solution.

[Relative atomic masses: A_r: H, 1; O, 16; Na, 23]

mass = g [2]

(ii) Use your chemical equation from (b)(ii) to calculate the number of moles of acid needed to neutralise this solution of sodium hydroxide.

number of moles = mol [1]

10 (a) Describe **two** differences between a mixture and a compound.

1.
.....
2.
..... [2]

(b) Sodium oxide and hydrogen sulfide are both compounds with very different properties.

Draw 'dot and cross' diagrams for sodium oxide and hydrogen sulfide. Only the outer shells of electrons need be shown.

[Atomic/proton numbers: H, 1; O, 8; S, 16; Na, 11]

sodium oxide

hydrogen sulfide

(c) Explain, in terms of structure and bonding, why:

(i) both solid sodium oxide and gaseous hydrogen sulfide do **not** conduct electricity.

.....
.....
.....

[3]

(ii) molten sodium oxide will conduct electricity.

.....
.....
.....

[1]

37. (A)

EXAM TIP:

The volume composition of gases present in dry air is approximately 78% nitrogen, 21% oxygen and the remainder (approximately 1%) comprises noble gases (with argon as the main constituent) and carbon dioxide.

38. (D)

Propane contains three carbon atoms, hence (A) is incorrect.

The general formula of alkanes is C_nH_{2n+2} , hence (B) is incorrect.

Complete combustion of alkanes produces carbon dioxide and water, hence (C) is incorrect.

Alkanes undergo substitution reaction with chlorine to produce chloroalkanes, hence (D) is correct.

EXAM TIP:

Recall the general physical and chemical properties of alkanes.

39. (C)

In addition polymerisation, the double bonds are broken and joined with another monomer to form the polymer.

EXAM TIP:

Identify the double bonds in the structure and deduce the structure of the repeat unit.

40. (C)

Alcohols undergo oxidation reaction in the presence of acidified potassium manganate(VII) to form carboxylic acids.

Thus, compound E is ethanol.

EXAM TIP:

Acidified potassium manganate(VII) solution is an oxidising agent.

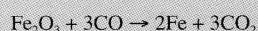
October/November 2019

Paper 3

Section A

1. (a) carbon monoxide

EXAM TIP:



(b) calcium hydroxide (or calcium oxide)

EXAM TIP:

When soil is too acidic, it can be treated with bases such as quicklime (calcium oxide) or slake lime (calcium hydroxide).

(c) yeast

EXAM TIP:

Yeast is added to glucose to produce ethanol and carbon dioxide.

(d) hydrogen

EXAM TIP:

To produce margarine, hydrogen is added to unsaturated vegetable oils.

2.

property	proton	neutron	electron
relative mass	1	1	$\frac{1}{1840}$
relative charge	1+	no charge	1-

3. (a) boiling point

EXAM TIP:

Fractional distillation is used to separate a mixture of miscible liquids with different boiling points.

(b) The vapour is cooled in the condenser and condenses into liquid, which is collected in the conical flask.

EXAM TIP:

In the condenser, the hot petroleum vapour condenses as running water cools it.

(c) Petrol fraction consists of a mixture of hydrocarbons. As it is a mixture of substances with different boiling points, it boils over a range of temperatures.

EXAM TIP:

Recall petroleum as a mixture of hydrocarbons and recall that a mixture boils over a range of temperatures.

(d) 1. Naphtha

2. Kerosene

(Other acceptable answers: diesel or lubricating oil.)

EXAM TIP:

Recall the different fractions of petroleum.

(e) (i) chloride ion

EXAM TIP:

Silver nitrate is used to test for the presence of chloride ions.

(ii) water

EXAM TIP:

Aqueous salt is a mixture of water and salt; hence water will be collected as distillate.

particle	number of		
	protons	neutrons	electrons
a chlorine atom $^{37}_{17}Cl$	17	20	17
a chloride ion $^{35}_{17}Cl^-$	17	18	18

(b) 1. When chlorine is above its boiling point, the molecules are far apart. When chlorine is below its melting point, the molecules are closely packed together in an orderly arrangement.

2. When chlorine is above its boiling point, the molecules move freely in all directions at high speed. When chlorine is below its melting point, the molecules only vibrate at their fixed positions.

EXAM TIP:

Recall the difference between solid and gaseous states in terms of kinetic particle theory.

5. (a) (i)	name	chemical formula
A ethene	C_2H_4	
B ethane	C_2H_6	

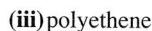
EXAM TIP:

Hydrogen gas can be added to ethene (an alkene), in the presence of nickel catalyst and at high temperature, to obtain ethane (an alkane).



EXAM TIP:

Ethene undergoes bromination to form 1,2-dibromoethane.



EXAM TIP:

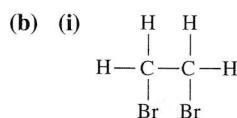
Ethene undergoes addition polymerisation to form polyethene.

(iv) Any one of the following:

- Substance D (polyethene) is a plastic which is non-biodegradable. Hence disposal of plastic waste in landfills leads to an increasing amount of built-up waste.
- Incineration of substance D (polyethene) will produce poisonous gases.
- As substance D (polyethene) is non-biodegradable, plastics thrown into the sea may endanger marine animals when they accidentally eat it.

EXAM TIP:

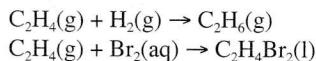
Recall the pollution problems caused by the disposal of non-biodegradable plastics.



EXAM TIP:

Substance C is $C_2H_4Br_2$.

(ii) Any one of the following:



EXAM TIP:

Ethene undergoes addition reactions with bromine and hydrogen respectively.

6. (a) 12

EXAM TIP:

The element with only two electrons in its third electron shell is magnesium.

(b) Group II
Period 3

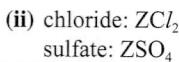
EXAM TIP:

The number of valence electrons indicates the group number. The number of electron shells indicates the period.

(c) (i) Elements in the same group have the same number of valence electrons. Since the chemical properties of an element depend on the number of valence electrons, the elements in the same group have similar chemical properties.

EXAM TIP:

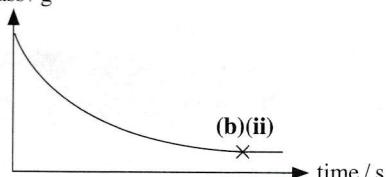
Chemical reactions involve only electrons and not neutrons, therefore elements with the same number of valence electrons have similar chemical properties.



EXAM TIP:

Z forms ions with $2+$ charge.

7. (a) mass / g



EXAM TIP:

In (a), as the reaction proceeds, the speed of reaction decreases, therefore the gradient of the mass-time graph slowly decreases to zero.

In (b), the point where the graph starts to become a straight line (i.e. gradient of the graph is zero), is when the reaction has stopped.

(b) (i) The gradient of the graph is the largest at the beginning of the reaction, indicating that the speed of reaction is the fastest.

As the reaction proceeds, the gradient decreases, indicating that the speed of reaction decreases.

The gradient becomes zero at the end of the reaction, indicating that the reaction has stopped as the hydrochloric acid is used up.

EXAM TIP:

The gradient at a point on the graph indicates the speed of reaction at that particular time. The larger the gradient, the faster the speed of reaction.

(c) The average speed of reaction can be calculated by taking the total change in mass from the reaction divided by the total time taken for the reaction.

EXAM TIP:

$$\text{Average speed of reaction} = \frac{\text{Total change in mass}}{\text{Total time taken}}$$

Section B

8. (a) (i) Any two of the following:

- Nickel has high melting points and boiling points.
- Nickel is a good conductor of heat and electricity.
- Nickel is malleable and ductile.

EXAM TIP:

Recall the general physical properties of metals.

(ii) test for hydrogen:

Place a lighted splint at the mouth of the test-tube. If hydrogen is present, the lighted splint extinguishes with a popping sound.

test for oxygen:

Place a glowing splint into the test-tube. If oxygen is present, the glowing splint relights.

(b) In the Mond process, only pure nickel will react with carbon monoxide to form gaseous nickel carbonyl, leaving the solid impurities behind. Further heating will decompose nickel carbonyl to form pure nickel solid and gaseous carbon monoxide, which will escape into the air.

EXAM TIP:

Identify the states of the reactants and products in the reactions.

(c) (i)

$$\begin{aligned}\text{Number of moles of Ni(CO)}_4 &= 1000 \div [59 + 4(12 + 16)] \\ &= 5.848 \text{ mol}\end{aligned}$$

$$\begin{aligned}\text{Number of moles of Ni} &= \text{number of moles of Ni(CO)}_4 \\ &= 5.848 \text{ mol}\end{aligned}$$

$$\begin{aligned}\text{Mass of Ni required} &= 5.848 \times 59 \\ &= 345 \text{ g (to 3 s.f.)}\end{aligned}$$

EXAM TIP:

$$\text{Number of moles} = \frac{\text{Mass}}{\text{Molar mass}}$$

(ii)

$$\begin{aligned}\text{Number of moles of CO} &= \text{Number of moles of Ni} \times 4 \\ &= 5.848 \times 4 \\ &= 23.39 \text{ mol}\end{aligned}$$

$$\begin{aligned}\text{Volume of CO} &= 23.39 \times 24 \\ &= 561 \text{ dm}^3 (\text{to 3 s.f.})\end{aligned}$$

EXAM TIP:

$$\text{Volume (dm}^3\text{)} = \text{Number of moles} \times \text{Molar volume}$$

9. (a) 1. Acids react with reactive metals to form a salt and hydrogen gas.

2. Acids react with carbonates to form a salt, water and carbon dioxide.

(Other acceptable answer: Acids react with metal oxides and hydroxides to form a salt and water only.)

EXAM TIP:

Recall the reactions that occur with acids.

(b) (i) Pipette 25.0 cm³ of sodium hydroxide solution into a conical flask and add one or two drops of methyl orange indicator into the solution. The solution should turn yellow.

Fill the burette with sulfuric acid and note the initial burette reading.

Add dilute sulfuric acid slowly into the sodium hydroxide solution in the conical flask, until the solution turns orange permanently. Record the volume of sulfuric acid required for the complete neutralisation reaction.

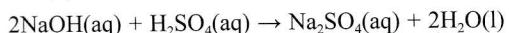
Repeat the titration without indicator and use the same amount of sulfuric acid added to prepare pure sodium sulfate solution.

EXAM TIP:

Recall the steps to prepare pure salt by titration method.

Another indicator that can be used is Phenolphthalein (colour of solution will change from pink to colourless).

(ii)



EXAM TIP:

acid + base \rightarrow salt + water

(c) (i)

Number of moles of NaOH = $3 \times 4 = 12$ mol
 Mass of NaOH required = $12 \times (23 + 16 + 1) = 480$ g

EXAM TIP:

$$\text{Concentration (mol / dm}^3) = \frac{\text{Number of moles of solute}}{\text{Volume (dm}^3)}$$

$$\text{Mass} = \text{Number of moles} \times \text{Molar mass}$$

(ii) Number of moles of H_2SO_4
 = number of moles of NaOH \div 2
 = $12 \div 2$
 = 6 mol

EXAM TIP:

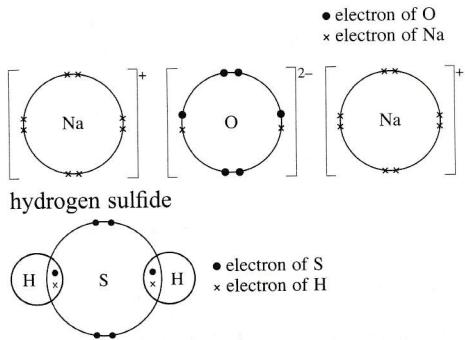
Use the balanced equation to find the mole ratio.

10. (a) 1. A mixture is made up of two or more substances that are not chemically combined, but a compound is made up of two or more elements that are chemically combined.
 2. The components of a mixture can be mixed in any ratio, but the elements in a compound are always combined in a fixed ratio.

(Other acceptable answers:

- The components of a mixture can be separated by physical processes, but a compound can only be broken down into its elements by chemical processes.
- The chemical properties of a mixture are the same as its components, but the physical and chemical properties of a compound are different from those of its constituent elements.)

(b) sodium oxide



EXAM TIP:

Sodium oxide is an ionic compound; hydrogen sulfide is a simple covalent compound.

(c) (i) Solid sodium oxide has a giant lattice structure with strong electrostatic forces of attraction between oppositely-charged ions. There are no mobile ions to conduct electricity as the ions are held in fixed position in the lattice structure.

Gaseous hydrogen sulfide has a simple molecular structure. There are no mobile ions or electrons to conduct electricity.

EXAM TIP:

Relate physical properties of ionic compounds to their lattice structure and covalent substances to their structure and bonding.

(ii) In the molten state, the giant lattice structure of sodium oxide is broken down, thus the ions are free to move and act as mobile charge carriers to conduct electricity.

EXAM TIP:

Recognise the difference between solid and molten states in the lattice structure.

October/November 2018

Paper 1

Multiple Choice Questions

21. (B)

The displacement method is suitable for insoluble gases as soluble gases would dissolve in water.

Upward delivery is used for gases less dense than air as they would displace air at the top of the gas jar.

EXAM TIP:

Displacement method (method 1) is used to collect gases which are not very soluble in water; upward delivery (method 2) is used to collect gases which are less dense than air.

22. (A)

Gas X is most likely to be ammonia, a basic gas that is soluble in water.

When ammonia is added to iron(III) nitrate, a reddish-brown precipitate is obtained instead of a green precipitate.

EXAM TIP:

Alkalies turn red litmus paper blue.

23. (B)

The atom contains 7 neutrons and 5 protons, and therefore has a nucleon (or mass) number of 12.

Since it has 5 protons, from the Periodic Table, the atom is boron.

EXAM TIP:

Each element is represented by a unique chemical symbol ${}^A_Z\text{X}$, where A is the nucleon number, Z is the proton number and X is the chemical symbol of the element.